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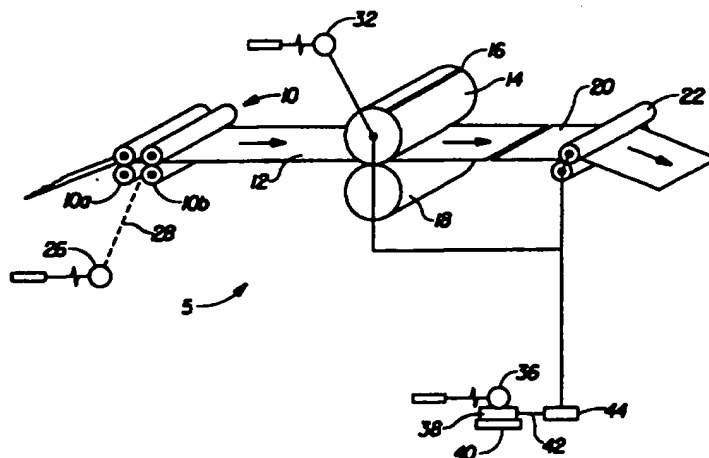
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(54) Title: DIAPER REGISTRATION CONTROL SYSTEM



(57) Abstract

The automatic registration control system of the present invention is a closed loop system including a driving mechanism (10) for feeding a continuous web (12) of disposable absorbent articles, such as diaper pads, toward a cutter (14). The cutter (14) may separate completed pads from the web. A sensor (26) is positioned along the manufacturing line, and preferably preceding the cutter (14), for detecting at least one preselected feature of each diaper pad and producing a detection signal when the feature passes by the sensor (26). A position resolver (32) determines the angular position of the cutter (14) at the moment when the preselected diaper feature is detected, and the average angular position is calculated from a predetermined number of cutter (14) positions. The average cutter (14) position is compared to and subtracted from a target cutter (14) position to produce an error signal. The error signal is then converted into a control signal and supplied to a phase variator (44) which adjusts the position of the cutter (14) in response to the control signal.

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DIAPER REGISTRATION CONTROL SYSTEM

FIELD OF THE INVENTION

This invention relates generally to a registration control system and more particularly to a closed-loop registration control system and method for controlling the location of a rotary knife cut on a web of material. The invention will be specifically disclosed in connection with a system for varying the angular position of a rotary cutter to change the phase relationship between the cutter and a preselected feature on a continuous web of interconnected diaper pads.

BACKGROUND OF THE INVENTION

In the manufacturing of disposable absorbent articles, such as diapers, adult incontinence articles, and sanitary napkins, it is a common manufacturing practice to initially fabricate a plurality of individual articles, such as diapers, that are serially spaced in interconnected positions on a continuous web. Individual diapers thereafter are formed by directing the web into a rotary cutter to cut the web between the spaced pads, usually as the final cutting operation in the manufacturing process.

In order to produce uniform diapers, and to eliminate waste, it is desirable to control relatively precisely the location at which the web is severed (typically referred to as the "final cut"). It is particularly desirable to cut the web in a correct position relative to features that are formed on the diaper. For example, disposable diapers frequently use adhesive tab strips and it is desirable to control the distance between these tabs and the top of the diaper within a relatively narrow tolerance.

Controlling the location of the final cut relative to other diaper features in an economically viable way has been and continues to be problematic for diaper manufacturers. Variation in the placement of the knife cut is inherent in the diaper manufacturing line equipment due to a number of factors including equipment wear, variations in raw materials, etc. Such variation in the final cut results in sequential pads that alternate between long and short

lengths. Web tension and temperature variations also occur when the pull rolls in the manufacturing line expand or contract as the line is placed into production. The increase in temperature makes the roll softer, allowing the web to compress the rolls. As the rolls are compressed, the surface of the roll increases, increasing the circumference of the roll. This results in an increase in the web speed through the roll. The diaper pads are advanced into the final knife with the increased effective pull roll speed, and as a result, beginning from a cold start, the final cut distance can shift significantly.

The variation in the final knife placement may steadily trend from one side of the specification limit to the other in a smooth transition, therefore making the detection of unacceptable variation difficult. Detecting unacceptable variation was previously left to the operators of the production line. This has been proven to be unacceptable in many instances because the variation can go undetected. Even when the variation can be detected by the line operator, it is usually at a point in time where an unacceptable level of product must be scrapped. Furthermore, inefficiencies are created because once the unacceptable variation is detected, the operator must manually adjust the system to correct the final knife placement.

Automatic registration control systems have been employed in web processing apparatus to overcome the problems of manual detection. For example, automatic registration control systems have been used in the manufacturing of price tags. In these systems, the tag web being fed is cut while its cut position is constantly corrected by a rotary blade. The blade is adjusted so that it can cut a variety of price tag webs having different cutting pitches or intervals. In these systems, after a tag is detected having a new cutting distance, the cutter is adjusted to correspond to the correct cutting position. This type of system has not been used in controlling the knife placement along the diaper web because the systems were not designed to accommodate extensible webs used in diaper production, but rather were designed as a means for adjusting the knife when a new cutting pitch or interval was necessary.

Attempts also have been made to control the rate at which a diaper web is fed to the cutter. However, this type of registration control system is undesirable because it requires multiple sensors located along the web, increasing the complexity of the registration system. In addition, adjusting

the web speed produces additional tensile stresses on the web by constantly changing the speed at which it is fed to the cutter. Considering that web tension problems are already inherent in diaper manufacturing lines, this problem is compounded by control systems which maintain the registration by continually adjusting the web speed.

Therefore, there exists a need for an automatic registration control system that controls the placement of the final cut with respect to a pre-selected feature of the diaper which eliminates the problems associated with previous registration control methods.

SUMMARY OF THE INVENTION

The present invention provides an automatic registration control system which eliminates the problem of excessive variation in the placement of the final cut that separates an individual disposable absorbent article, such as a diaper, from a continuous web of completed pads. The automatic registration control system of the present invention is a closed loop system that includes a driving mechanism for feeding a continuous web of diaper pads toward a rotary cutter. A sensor is positioned along the manufacturing line upstream or downstream of the rotary cutter for detecting at least one preselected feature of each diaper pad and producing a detection signal when the feature passes by the sensor. A position resolver determines the angular position of the rotary cutter at the moment when the preselected diaper feature is detected, and the average angular position is calculated from a predetermined number of cutter positions. The average cutter position is compared to and subtracted from a target cutter position to produce an error signal. The error signal is then converted into a control signal and supplied to a phase variator which adjusts the rotational position of the rotary cutter in response and proportionally to the control signal.

The target cutter position is present at a value determined by an operator, who must manually advance or retard the phase of the final knife until the final cut is in the proper location. Once the proper registration has been achieved, the operator switches over the line to automatic mode. A new target position is then calculated by using the knife positions corresponding to the first 25 pads to be scanned by the sensor. An average knife position is continually calculated using the 25 most recent positions stored in memory as scanned by the sensor.

Any deviation of the average knife position from the target value results in the error signal being supplied to a proportional compensator, which generates the control signal. The control signal is then supplied to a velocity controlled servo, which in turn drives, through a gear box, a correction shaft of the phase variator. The phase variator either advances or retards the phase of the final knife so as to bring the error closer to zero. The control system detects and adjusts to any changes in the average placement of the final cut.

Consequently, it is an object of the invention to reduce the variation in the placement of a knife cut with respect to a preselected diaper feature by controlling the angular position of a rotary cutter based upon the average angular position of the rotary cutter when the preselected feature is detected.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings, in which it is understood to be illustrated by a diaper control system, but generally applicable to disposable absorbent article control systems:

Fig. 1 is a schematic diagram of the final knife cutting operation of a diaper line;

Fig. 2 is a top view of a diaper web wherein the diapers include a fastening system and a core; and

Fig. 3 is a flow diagram of the registration control system of Fig. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention has been designed to reduce the variation in the placement of a knife cut along the continuous diaper web using the approach of a closed loop registration control system. The system may also be used to control the relative positions of any two features of the diaper, so that one feature may be operated on, e.g. by attachment to the diaper, cutting from stock, calendaring, straining, printing, spinning, etc., in special relationship relative to the other feature.

Fig. 1 illustrates the invention as incorporated in controlling the placement of the knife cut in relation to the diaper fastening tabs. In Fig. 1,

the control system 5 includes two sets of pull rolls 10 for feeding a continuous web 12 of diaper pads along a path towards knife 14. Pull rolls 10 are mechanically driven at a preselected speed by external means (not shown). The knife includes a blade 16 positioned along the surface of the knife which rotates above an anvil 18 for separating a completed diaper 20 from the web 12. The separated diaper 20 continues through nip rolls 22 to a final folding station (not shown).

The registration control system 5 further includes an ultraviolet luminescence scanner 26, preferably positioned between or after pull roll sets 10a and 10b, and selected to detect at least one preselected feature of each diaper 20 on the web 12 as it passes beneath the scanner 26. The preferred scanner 26 is an optical sensor, such as an Optics LUT 1-4 sensor, manufactured by Sick Co., that emits a modulated ultraviolet light beam 28 towards the web. The ultraviolet luminescence scanner 26 works well for a luminescing preselected feature, against a nonluminescing background. When the preselected feature, such as when fastening tabs 30 pass beneath the ultraviolet beam 28, the tabs emit light at the same modulated frequency as the scanner 26. If the preselected feature and the background have different opacities, an infra-red scanner may be selected. The diaper feature selected for detection may be the fastening tabs 30, as shown in Fig. 2, or may be the edge of the core, or the dedicated fastening surface, etc. The scanner 26 produces a detection signal when it detects a change in the light emitted by, reflected by, absorbed by, or transmitted through the preselected feature.

The scanner 26 should be mounted as near the knife 14 as practical because, as the unit is placed closer to the final cut 33, the control system 5 will better detect changes occurring upstream, and hence become more accurate at predicting the point of cut in relation to the fastening tabs 30. The exact position of the scanner 26 must be balanced with the convenience of mounting the scanner along the line and its likelihood of contamination in various locations.

The angular position of the rotary knife 14 is determined by means of a position resolver 32 which reads the angular position of the knife at the time the fastening tabs are detected by the scanner 26. The angular position of the knife 14 is initially set at a target value determined by an operator, who must initially manually advance or retard the phase of the knife until the

location of final cut 33 (Fig. 2) is in the proper location with respect to the fastening tabs 30. Once the proper registration has been achieved, the operator switches over the line to automatic mode through a control panel (not shown). Once in automatic mode, at least five diaper pads, and particularly the first twenty-five diaper pads are scanned and the angular position of the cutter is stored and averaged. The average angular position of the cutter represents the average distance between the fastening tabs and the final cut. This average angular position is stored as a new target value which is more accurate than the first manually set target value.

As the web is processed, an average knife position is continually calculated using the twenty-five most recent angular positions of knife 14 and stored in memory as a twenty-five point moving average. Any deviation of the twenty-five point moving average from the new target value results in the generation of an error signal. The error signal is fed into a proportional compensator 36 which generates a control signal. The control signal may be supplied to a fixed velocity servo 38, or more preferably to a velocity controlled servo 38 which drives through a gear box 40 a correction shaft 42 of a phase variator 44, preferably manufactured by Specon Co. The phase variator 44 either advances or retards the rotational phase of the final knife 14 to compensate for the error.

Referring now to Fig. 3, the method of controlling the variation in the placement of a knife cut along the continuous web of diaper pads is illustrated. The system has been programmed to perform the following steps. The first step is establishing a target knife position illustrated as block 50. The target knife position 50 is arrived at by manually advancing, illustrated as block 52, or retarding, illustrated as block 54, the phase of the knife, by advancing, illustrated as block 57, or retarding illustrated as block 59, the phase variator which adjusts final knife position. Once the target knife position 50 has been established, the control system is placed in the automatic mode, illustrated as block 60, wherein a new target value, illustrated as block 62, is determined. New target value 62 is the average angular position of the knife calculated from the first twenty-five diaper pads scanned. The target knife position may be adjusted in the automatic mode, as illustrated by block 50 by adding or subtracting counts to or from the target position 50 as illustrated by blocks 56 and 58 respectively.

The next step is detecting, illustrated as block 64, the preselected feature of an individual diaper pad along the continuous web of pads and producing a detection signal as the preselected feature passed beneath the scanner. The angular position of the knife is read, illustrated by block 66, by the position resolver as the fastening tabs are detected. The knife position at the time tabs are detected is compared, illustrated as block 68, to see whether it is within an acceptable range of the new target value. If a knife position datum point is not within the acceptable range, the current twenty-five diaper average, illustrated as block 70, is used as the next data point and the twenty-five point moving average is recalculated using the twenty-five pad average as the new data point and dropping the 26th (oldest) pad datum point as illustrated as block 72. This is done to prevent any one erroneous diaper reading from unduly affecting the twenty-five diaper average and causing an improper change in the position of the knife. The twenty-five point moving average 72 is subtracted, illustrated as block 74, from the new target value 50 to produce an error signal, illustrated as block 76. The error signal is converted, illustrated as block 80, by the proportional compensator into a control signal and supplied to the servo for correction, illustrated as block 80, of the knife position. When the system is not in automatic mode the error is ignored 81.

By computing a twenty-five point moving average, the phase of the knife will be properly adjusted based upon long term variations in the process, rather than any one diaper being improperly cut. Consequently, knife adjustments will be more accurate because they will need to be adjusted less frequently. A predetermined number of diaper pads, e.g. at least 25, may be ignored after start-up of the system. Thus, this number of pads is not used in computing the predetermined average. This allows the system to achieve steady state, thereby minimizing premature adjustments in cutter position.

While the invention has been described in conjunction with the automatic registration control of the knife position with respect to the fastening tabs, dedicated fastening surface or edge of the core, it is to be understood that alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. For example, the invention can be utilized in other areas of the diaper manufacturing process to control registration of any feature of the diaper relative to another feature

of the diaper. Accordingly, the invention is intended to embrace all such alternatives, modifications, and variations as fall within the spirit and broad scope of the appended claims.

WHAT IS CLAIMED IS:

1. A closed-loop registration control system for a disposable absorbent article manufacturing line comprising:
 - means for feeding a continuous web of disposable absorbent articles along a path;
 - a sensor for detecting at least one preselected feature of each disposable absorbent article and producing a detection signal when said feature passes by said sensor;
 - a rotary cutter, said cutter disposed in angular position relative to said feature;
 - means for determining the angular position of said cutter at the moment when said preselected feature is detected;
 - means for calculating the average of a predetermined number of said cutter positions corresponding to a number of consecutive disposable absorbent articles which have passed by said detection means;
 - means for subtracting from said average cutter position a predetermined target cutter position so as to produce an error signal; and
 - means for converting said error signal into a control signal and supplying said control signal to a phase modifying means;characterized in that said means for modifying the phase of said rotary cutter modifies said cutter position in response to said control signal.
2. The control system of Claim 1 characterized in that said phase modifying means modifies said cutter position proportionally to said control signal.
3. The control system of Claims 1 and 2 characterized in that said feeding means is at least one set of pull rolls, and preferably comprises two sets of pull rolls wherein said scanner is positioned between said pull rolls.

4. The control system of Claims 1, 2, and 3 characterized in that phase modifying means is a velocity controlled servo and a phase variator.
5. The registration control system of Claims 1, 2, 3, and 4 characterized in that said continuous web of disposable absorbent articles moves at a predetermined speed, said cutter position being maintained relative to said preselected feature independently of said predetermined speed, and preferably said average predetermined number of said stored cutter positions corresponds to at least five consecutive disposable absorbent articles.
6. A closed-loop registration control system for controlling the placement of a knife cut with respect to a preselected feature of an individual diaper pad along a continuous web of completed diaper pads comprising:
 - at least one pull roll for advancing said web along a diaper line;
 - a rotary knife for performing said cut;
 - a scanner positioned along said diaper line at a location juxtaposed with said rotary knife;
 - said scanner simultaneously detecting and producing a detection signal as said preselected feature passes by said scanner;
 - a position resolver connected to said knife for determining the angular position of said knife when said preselected feature is detected;
 - means for calculating an average knife position based upon a preselected number of said preselected feature being detected;
 - means for subtracting from said average knife position a preselected target knife position, thereby producing an error signal;
 - a proportional compensator for converting said error signal into a control signal; and
 - a servo, which in response to said control signal, drives a phase variator to correct the placement of said knife cut.
7. The control system of Claim 6 characterized in that said cutter position for each said diaper is determined to be inside or outside a predetermined range, and preferably if said cutter position is outside said acceptable range, said average of said predetermined number of

each pads is used as the next cutter position in calculating said average.

8. The control system of Claims 6 and 7 characterized in that, immediately after start-up of said system, said system does not make a change in said position of said cutter until a predetermined number of positions of said preselected features have been determined.
9. A method for controlling the angular position of a cutter in a diaper line comprising the steps of:
 - establishing a target knife position;
 - detecting at least one preselected feature of said diaper pad and producing a detection signal as said feature passes by a detection means;
 - determining an angular position of said knife when said preselected feature is detected;
 - storing said angular position;
 - comparing said angular position to said target position;
 - calculating an average knife position from a predetermined number of stored angular positions corresponding to a number of consecutive pads which have passed by said detection means;
 - subtracting said target position from said average position to produce an error signal;
 - converting said error signal into a control signal and supplying said control signal to a cutter position modifying means; and
 - modifying said angular position of said cutter in response to said control signal.
10. The method of Claim 9 characterized in that said detecting step further comprises the steps of:
 - emitting a light beam by said detection means upon said web;
 - detecting a change in said light beam caused by said preselected feature of said diaper pad as said preselected feature moves relative to said detection means; and
 - sensing said change in said light beam, and preferably said step of modifying said angular position of said cutter further includes the step of driving a phase variator connected to said cutter.

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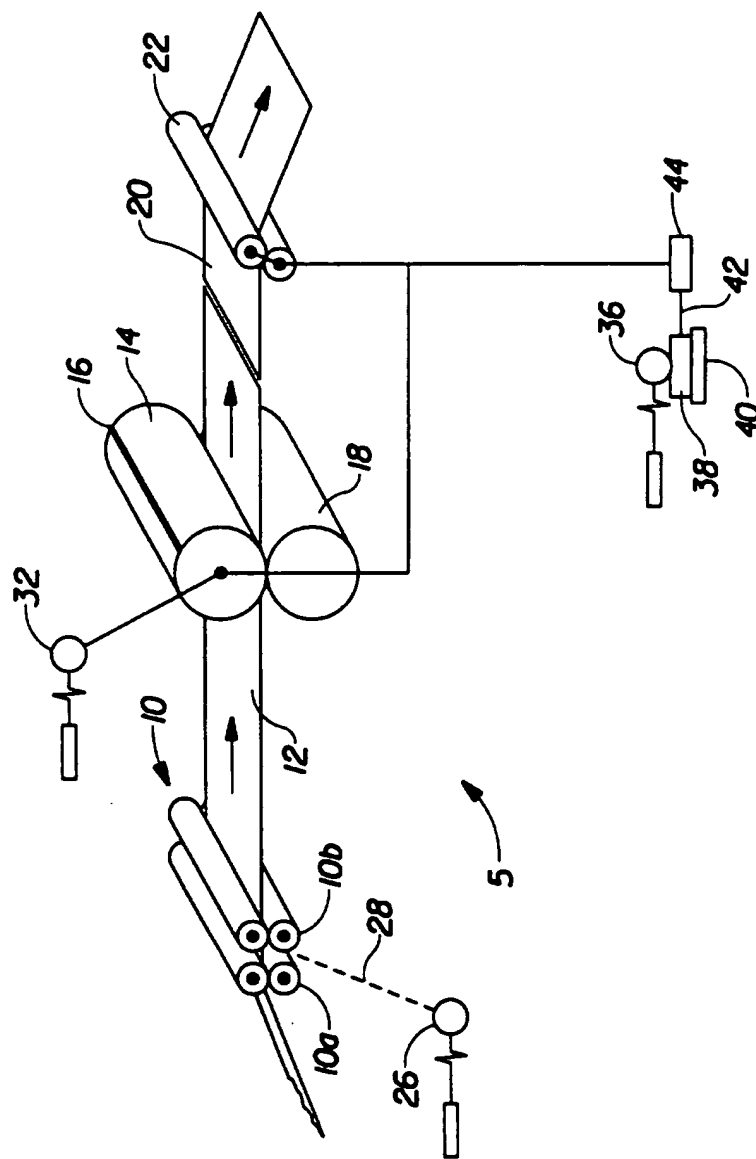


Fig. 1

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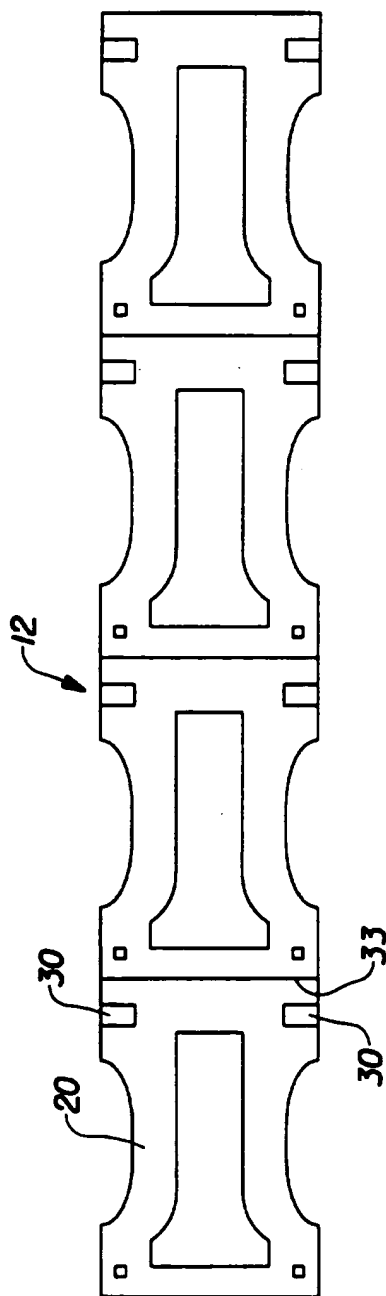
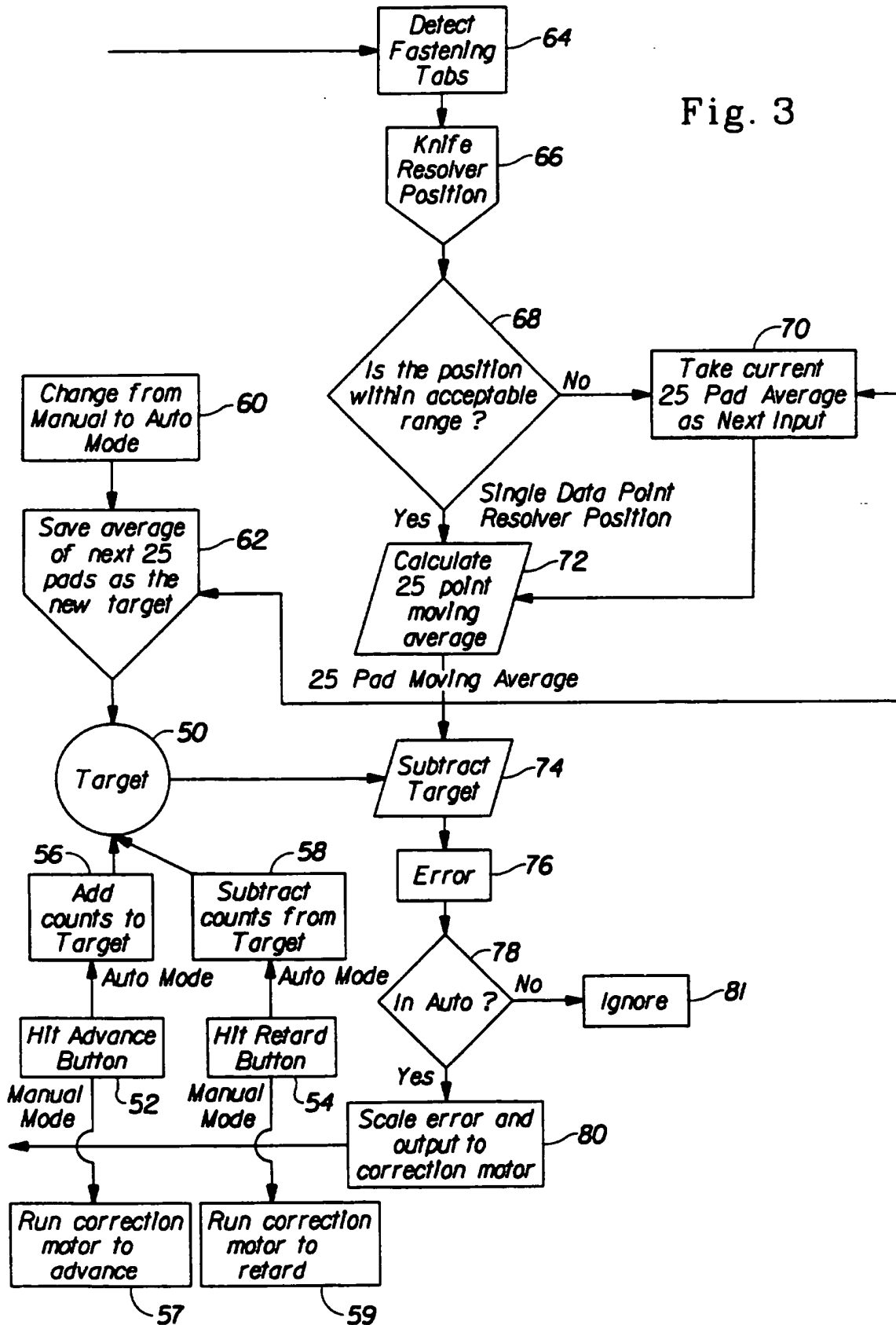


Fig. 2

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Fig. 3



INTERNATIONAL SEARCH REPORT

Int: nal Application No

PCT/US 96/02385

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61F13/15

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,4 669 344 (HERRIG) 2 June 1987 see column 2, line 1 - column 3, line 9; claims; figures ---	1-10
A	US,A,4 736 446 (REYNOLDS ET AL.) 5 April 1988 see abstract; claims; figures ---	1-10
A	US,A,4 781 090 (FELDKAMPER ET AL) 1 November 1988 ---	
A	US,A,4 279 369 (PASSAFIUME) 21 July 1981 ---	
A	EP,A,0 267 861 (CELATOSE SA) 18 May 1988 -----	

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Date of the actual completion of the international search

7 June 1996

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information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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